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(54) **PUMP-THROUGH STANDING VALVES, WELLS INCLUDING THE PUMP-THROUGH STANDING VALVES, AND METHODS OF DEPLOYING A DOWNHOLE DEVICE**

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E21B 34/08 (2006.01)
E21B 34/10 (2006.01)
E21B 23/10 (2006.01)

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CPC ***E21B 34/10*** (2013.01); ***E21B 23/10*** (2013.01); *E21B 2200/05* (2020.05)

(58) **Field of Classification Search**
CPC E21B 34/06; E21B 34/10; E21B 34/08
See application file for complete search history.

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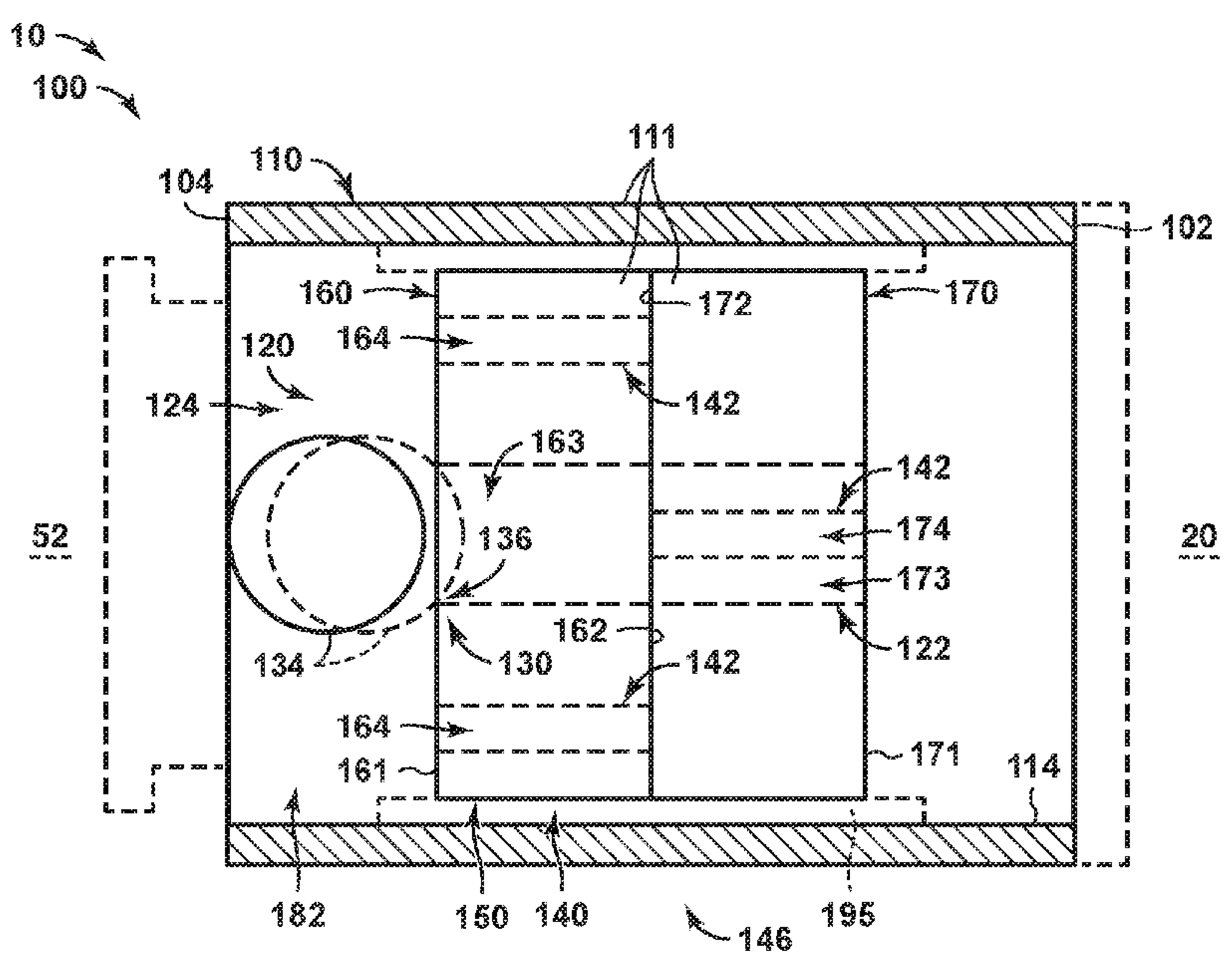
(57) **ABSTRACT**

Pump-through standing valves, wells including the pump-through standing valves, and methods of utilizing a pump-through standing valve to deploy a downhole device are disclosed herein. The pump-through standing valves include a valve body, a standing valve at least partially formed within the valve body, and a flow-through valve at least partially formed within the valve body. The standing valve includes a standing valve fluid conduit and a standing valve flow control device. The flow-through valve includes a flow-through valve fluid conduit and a flow-through valve flow control device. The wells include a wellbore, which extends within a subterranean formation, a wellbore tubular, which extends within the wellbore, and the pump-through standing valve, which is operatively attached to the wellbore tubular.

18 Claims, 5 Drawing Sheets



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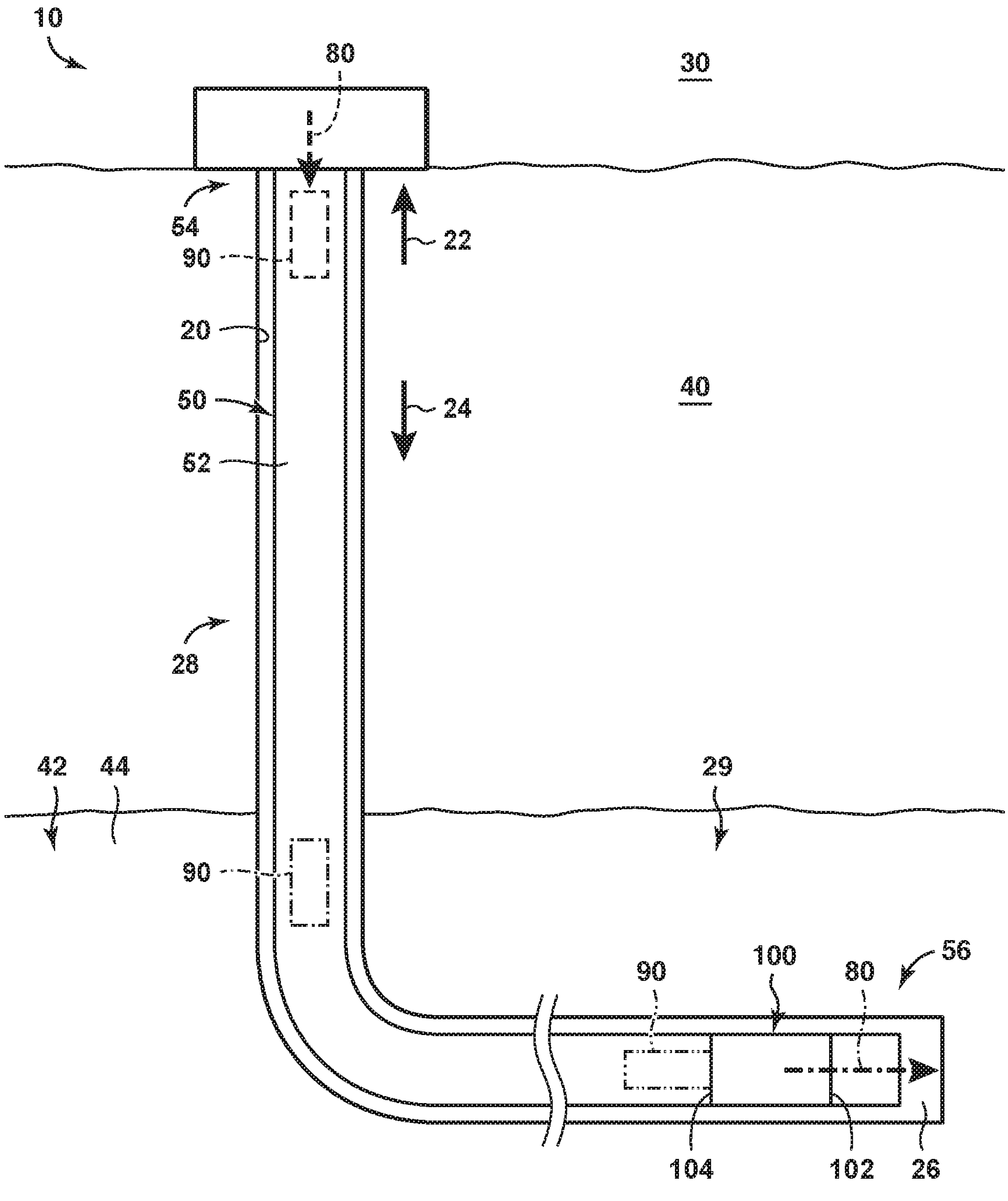

FIG. 1

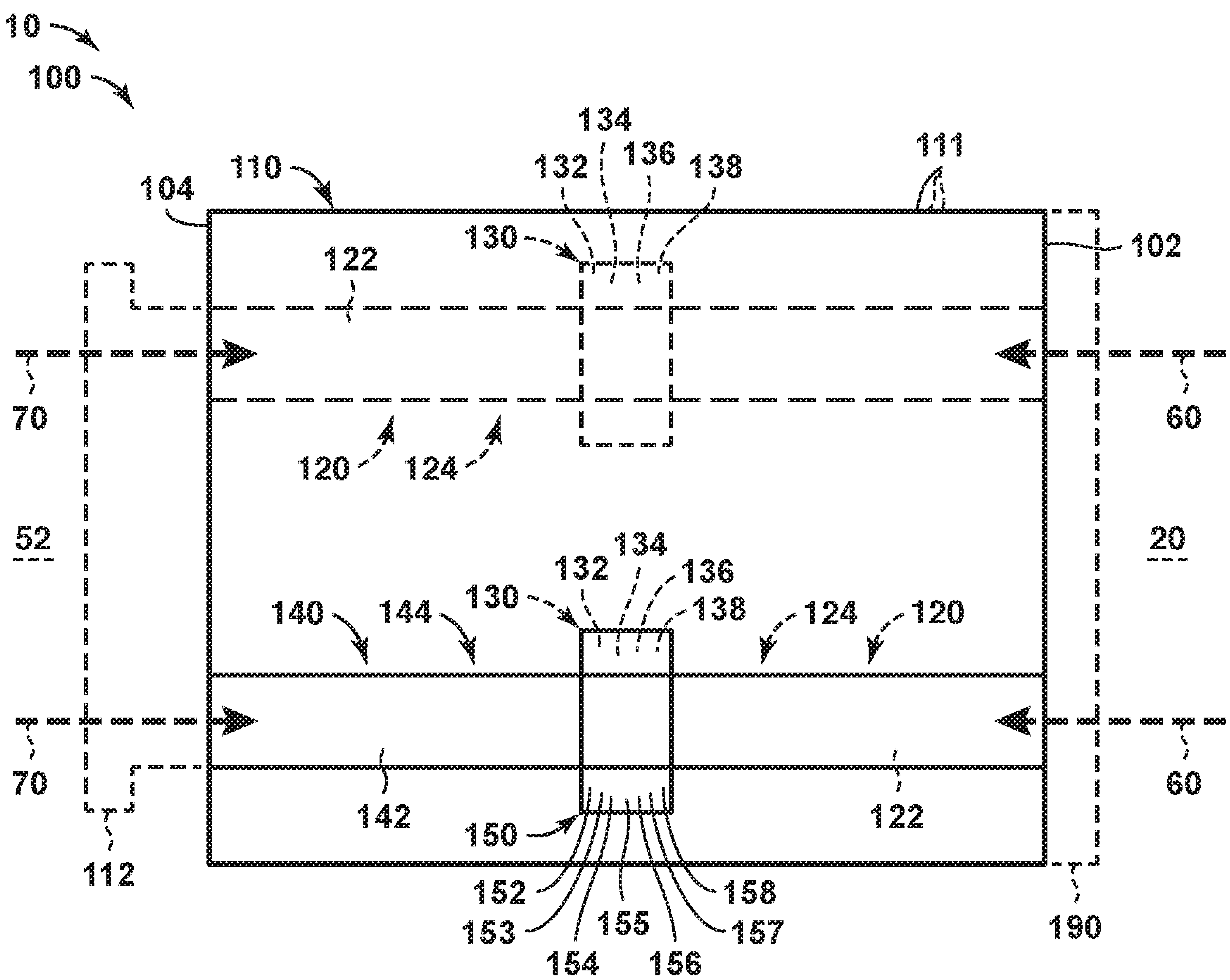
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FIG. 2

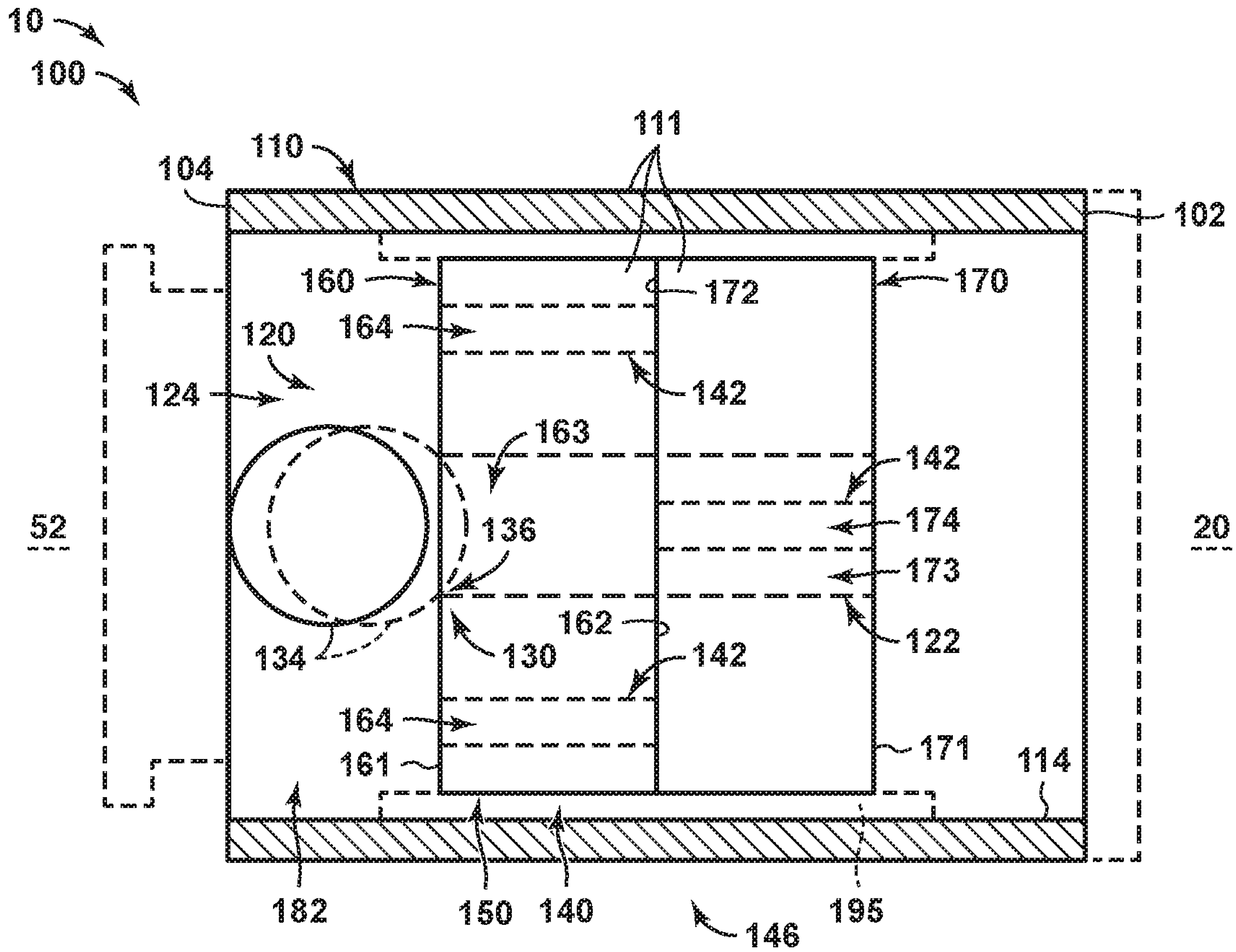
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FIG. 3

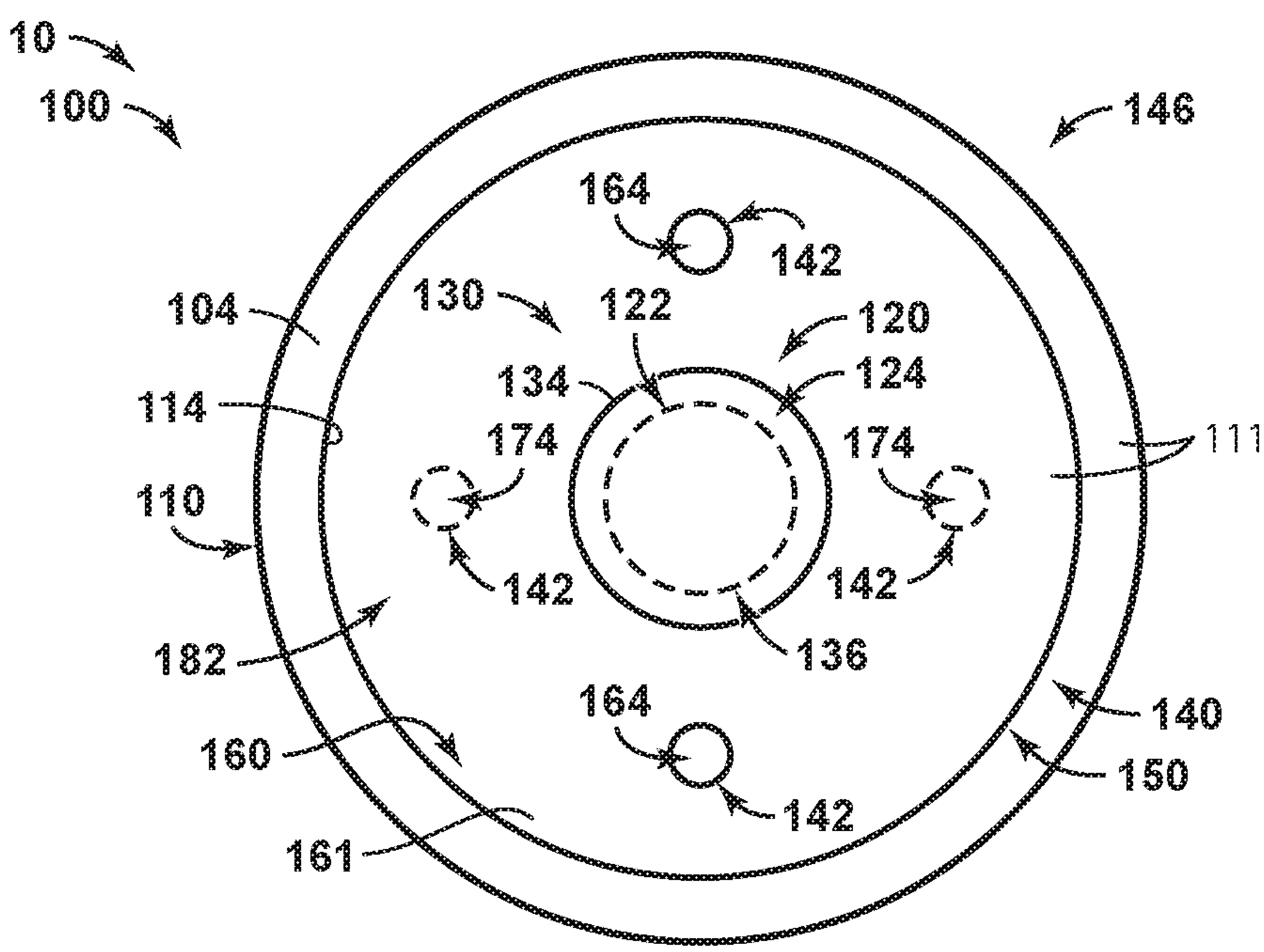
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FIG. 4

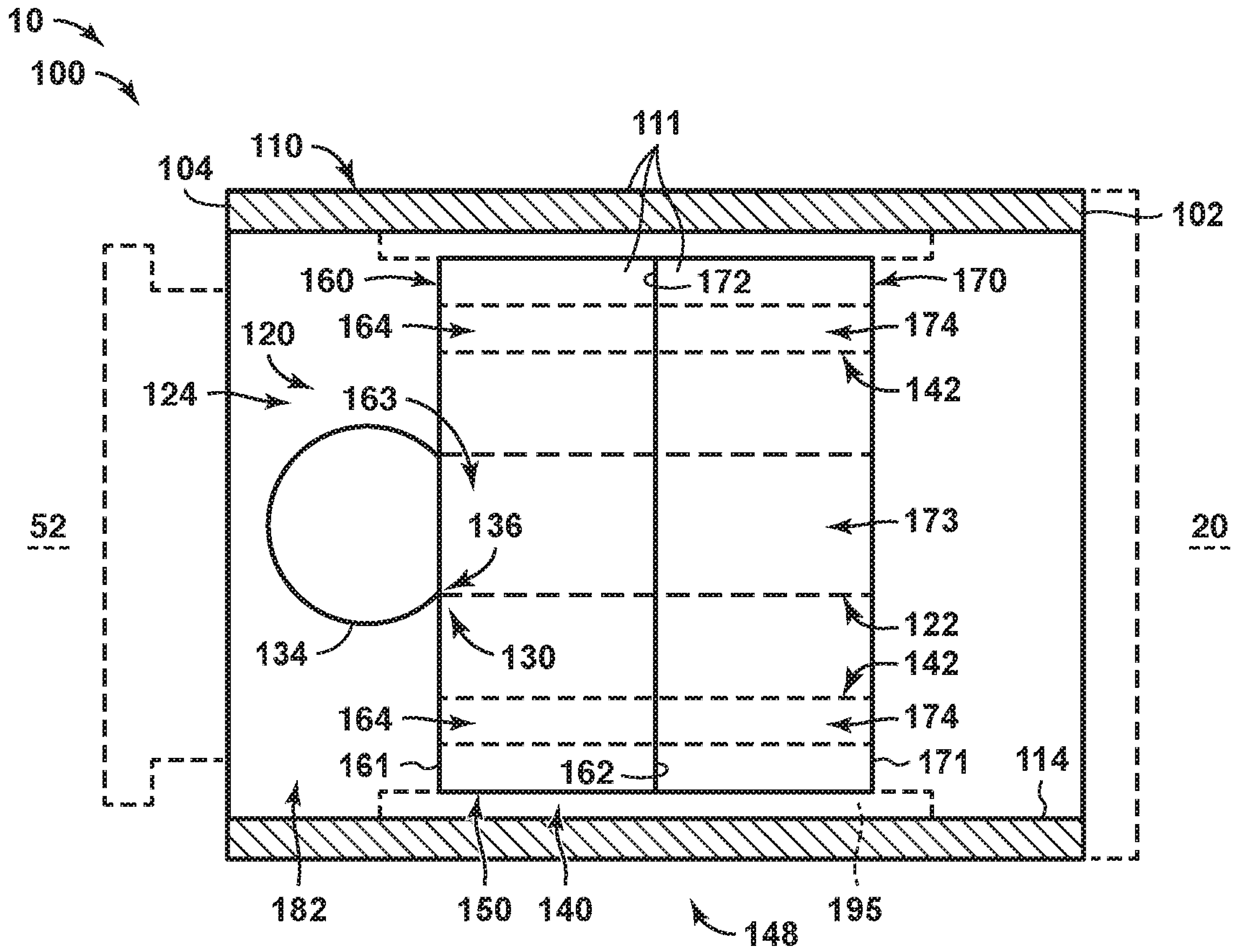
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FIG. 5

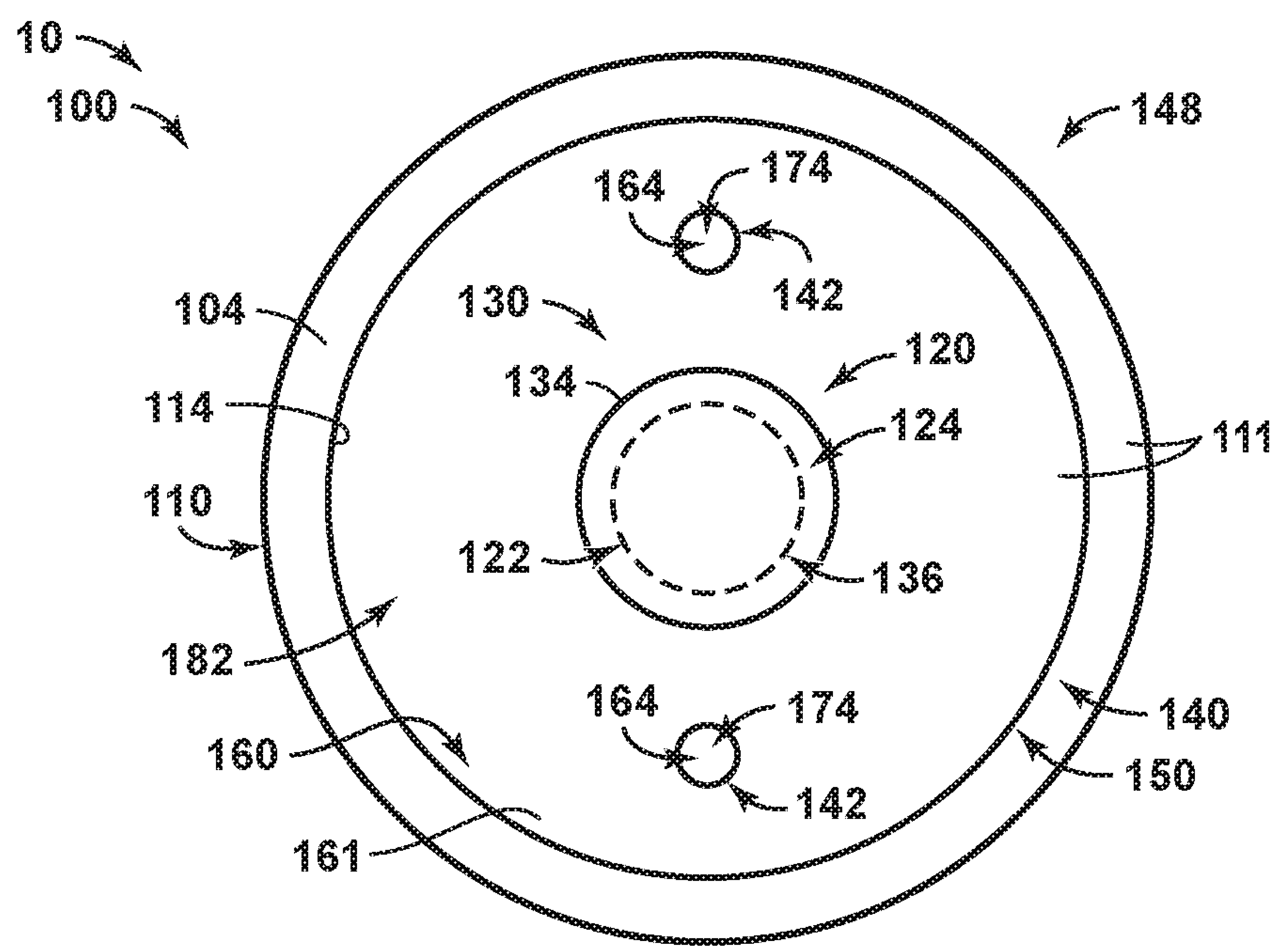
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FIG. 6

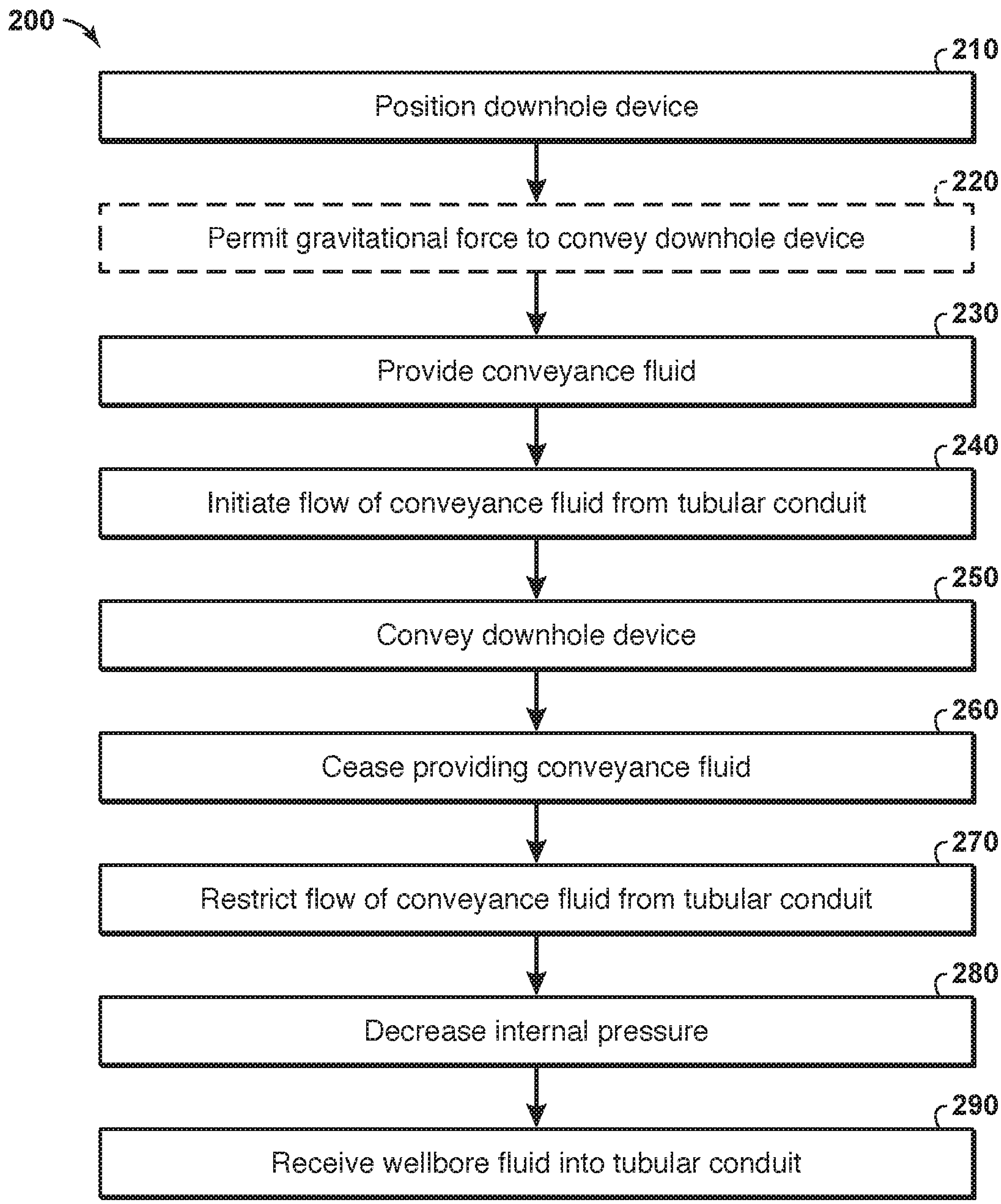
200
210
Position downhole device
220
Permit gravitational force to convey downhole device
230
Provide conveyance fluid
240
Initiate flow of conveyance fluid from tubular conduit
250
Convey downhole device
260
Cease providing conveyance fluid
270
Restrict flow of conveyance fluid from tubular conduit
280
Decrease internal pressure
290
Receive wellbore fluid into tubular conduit

FIG. 7

PUMP-THROUGH STANDING VALVES, WELLS INCLUDING THE PUMP-THROUGH STANDING VALVES, AND METHODS OF DEPLOYING A DOWNHOLE DEVICE

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application Ser. No. 62/422,303, filed Nov. 15, 2016, entitled "Pump-Through Standing Valves, Wells Including the Pump-Through Standing Valves, and Methods of Deploying a Downhole Device," the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

The present disclosure is directed generally to pump-through standing valves, to wells including pump-through standing valves, and/or to methods of utilizing a pump-through standing valve to deploy a downhole device.

BACKGROUND OF THE DISCLOSURE

Wells, such as hydrocarbon wells, include a wellbore that extends within a subterranean formation. Such wells also may include a wellbore tubular, such as a casing string and/or a tubing string, that extends within the wellbore and defines a tubular conduit. Under certain conditions, a downhole, or toe, end of the wellbore tubular includes, is associated with, and/or has attached thereto a standing valve. The standing valve is configured to permit a fluid inflow from the wellbore into the tubular conduit and also to resist a fluid outflow from the tubular conduit into the subterranean formation. Such a configuration may facilitate production of a reservoir fluid, such as a hydrocarbon, from the subterranean formation while, at the same time, retaining the reservoir fluid within the tubular conduit under conditions in which a pressure within the tubular conduit is greater than a pressure within the subterranean formation.

While the presence of the standing valve many be beneficial to the overall operation of the well, it may make it difficult to position, or at least to economically position, a downhole device within the tubular conduit and/or near a downhole end of the tubular conduit, especially when the tubular conduit extends within a horizontal and/or deviated well. Thus, there exists a need for pump-through standing valves, for wells including the pump-through standing valves, and/or for improved methods of utilizing pump-through standing valves to deploy downhole devices.

SUMMARY OF THE DISCLOSURE

Pump-through standing valves, wells including the pump-through standing valves, and methods of utilizing pump-through standing valves to deploy downhole devices are disclosed herein. The pump-through standing valves include a valve body, a standing valve at least partially formed within the valve body, and a flow-through valve at least partially formed within the valve body. The standing valve includes a standing valve fluid conduit and a standing valve flow control device. The standing valve fluid conduit extends between a wellbore-exposed region of the valve body and a tubular conduit-exposed region of the valve body. The standing valve flow control device is configured to permit a fluid inflow via the standing valve fluid conduit and to resist a fluid outflow via the standing valve fluid conduit. The flow-through valve includes a flow-through valve fluid conduit and a flow-through valve flow control device. The flow-through valve fluid conduit extends between the wellbore-exposed region of the valve body and the tubular conduit-exposed region of the valve body. The flow-through valve flow control device is configured to selectively permit the fluid outflow via the flow-through valve fluid conduit when an outflow pressure differential exceeds a threshold outflow pressure differential. The flow-through valve flow control device further is configured to selectively restrict the fluid outflow when the outflow pressure differential is less than the threshold outflow pressure differential.

The wells include a wellbore, which extends within a subterranean formation, and a wellbore tubular, which extends within the wellbore. The wells also include the pump-through standing valve, and the pump-through standing valve is operatively attached to the wellbore tubular.

The methods include methods of utilizing the pump-through standing valve and/or the well to deploy a downhole device. These methods include positioning a downhole device within an uphole region of a tubular conduit, which is defined by a wellbore tubular that extends within a wellbore that extends within a subterranean formation. The methods also include providing a conveyance fluid to an uphole region of the tubular conduit to pressurize the tubular conduit such that an outflow pressure differential is at least a threshold outflow pressure differential. The methods further include initiating flow of the conveyance fluid from the tubular conduit via a flow-through valve fluid conduit of the pump-through standing valve responsive to the outflow pressure differential exceeding the threshold outflow pressure differential. The methods also include conveying the downhole device within the tubular conduit and in a downhole direction within the conveyance fluid to position the downhole device within a target region of the tubular conduit. The methods then include ceasing the providing the conveyance fluid such that the outflow pressure differential decreases to less than the threshold outflow pressure differential and restricting flow of the conveyance fluid through the flow-through valve fluid conduit responsive to the outflow pressure differential decreasing to less than the threshold outflow pressure differential. The methods further include decreasing an internal pressure within the tubular conduit such that an inflow pressure differential is at least a threshold inflow pressure differential and subsequently receiving a wellbore fluid into the tubular conduit via a standing valve fluid conduit of the pump-through standing valve.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic cross-sectional view of a well including a pump-through standing valve, according to the present disclosure.

FIG. **2** is a schematic representation of pump-through standing valves according to the present disclosure.

FIG. **3** is a less schematic cross-sectional view of a pump-through standing valve, according to the present disclosure, illustrating a flow-through valve thereof in a closed state.

FIG. **4** is a top view of the pump-through standing valve of FIG. **3**.

FIG. **5** is a cross-sectional view of the pump-through standing valve of FIGS. **3**-**4** illustrating the flow-through valve in an open state.

FIG. 6 is a top view of the pump-through standing valve of FIG. 5.

FIG. 7 is a flowchart depicting methods, according to the present disclosure, of utilizing a pump-through standing valve to deploy a downhole device.

DETAILED DESCRIPTION AND BEST MODE OF THE DISCLOSURE

FIGS. **1-7** provide examples of pump-through standing valves **100**, of wells **10** including pump-through standing valves **100**, and/or of methods **200** of utilizing a pump-through standing valve to deploy a downhole device, according to the present disclosure. Elements that serve a similar, or at least substantially similar, purpose are labeled with like numbers in each of FIGS. **1-7**, and these elements may not be discussed in detail herein with reference to each of FIGS. **1-7**. Similarly, not all elements may be labeled in each of FIGS. **1-7**, but reference numerals associated therewith may be utilized herein for consistency. Elements, components, and/or features that are discussed herein with reference to one or more of FIGS. **1-7** may be included in and/or utilized with any of FIGS. **1-7** without departing from the scope of the present disclosure. In general, elements that are likely to be included in a particular embodiment are illustrated in solid lines, while elements that are optional are illustrated in dashed lines. However, elements that are shown in solid lines may not be essential and, in some embodiments, may be omitted without departing from the scope of the present disclosure.

FIG. **1** is a schematic cross-sectional view of a well **10** including a pump-through standing valve **100**, according to the present disclosure. Well **10** includes a wellbore **20** that extends within a subterranean formation **42**. Wellbore **10** also may be referred to herein as extending within a subsurface region **40** that includes subterranean formation **42**, as extending between a surface region **30** and subsurface region **40**, and/or as extending between the surface region and the subterranean formation. Wellbore **20** may include a vertical, or at least substantially vertical, portion, or region, **28**. Additionally or alternatively, wellbore **20** also may include a deviated, a horizontal, or an at least substantially horizontal portion, or region, **29**.

Subterranean formation **42** may include a reservoir fluid **44**, such as a hydrocarbon fluid, and well **10** may be utilized to facilitate production of the reservoir fluid from the subterranean formation. When the reservoir fluid includes the hydrocarbon fluid, well **10** also may be referred to herein as a hydrocarbon well **10**.

Well **10** also includes a wellbore tubular **50**, such as a casing string and/or a tubing string, that extends within wellbore **20** and defines a tubular conduit **52**. Pump-through standing valve **100** also may be referred to herein as a valve assembly **100**, a standing valve assembly **100**, and/or a pump-through standing valve assembly **100**. Pump-through standing valve **100** is operatively attached to a downhole portion, region, and/or end, **56** of wellbore tubular **50**. This operative attachment may be such that a wellbore-exposed region **102** of pump-through standing valve **100** is exposed to, faces toward, and/or is in fluid contact with wellbore **20**. In addition, the operative attachment also may be such that a tubular conduit-exposed region **104** of pump-through standing valve **100** is exposed to, faces toward, and/or is in fluid contact with tubular conduit **52**. Stated another way, tubular conduit-exposed region **104** may at least partially define tubular conduit **52** and/or wellbore tubular **50** may separate tubular conduit-exposed region **104** from wellbore **20**, from subsurface region **40**, and/or from subterranean formation **42**.

As also illustrated in FIG. **1**, a wellbore fluid **26** may extend within wellbore **20** and/or within tubular conduit **52**. This wellbore fluid may include, or be, reservoir fluid **44**. Additionally or alternatively, this wellbore fluid may include, or be, another fluid that is provided to the wellbore from surface region **30**.

As further illustrated in FIG. **1**, well **10** and/or wellbore **20** thereof may define an uphole portion, region, and/or end **54**, and the uphole portion may be proximate, may be near, and/or may open into surface region **30**. Stated another way, uphole portion **54** may be uphole from, or located in an uphole direction **22** from, downhole portion **56**. Conversely, downhole portion **56** may be downhole from, or located in a downhole direction **24** from, uphole portion **54**.

During operation of wells **10** that include wellbores **20**, wellbore tubulars **50**, and pump-through standing valves **100**, it may be desirable to position a downhole device **90** within tubular conduit **52** and/or within a portion of the tubular conduit that extends within deviated portion **29** of wellbore **20**. Examples of downhole device **90** include any suitable pump, well control device, barrier, and/or sensor.

Under these conditions, and as discussed in more detail herein with reference to methods **200** of FIG. **7**, downhole device **90** may be positioned within uphole region **54** of tubular conduit **52**, as illustrated in dashed lines in FIG. **1**. A conveyance fluid **80** then may be provided to the tubular conduit to pressurize the tubular conduit and/or to generate an outflow pressure differential across pump-through standing valve **100**. The outflow pressure differential is defined when, or such that, an internal pressure exerted on tubular conduit-exposed region **104** exceeds an external pressure exerted on wellbore-exposed region **102**.

When the outflow pressure differential is at least, or exceeds, a threshold outflow pressure differential, pump-through standing valve **100** permits a fluid outflow of the conveyance fluid to flow from the tubular conduit and into the subterranean formation, as illustrated in dash-dot lines in FIG. **1**. Thus, the pump-through standing valve permits and/or establishes a flow of the conveyance fluid within tubular conduit **52** and in downhole direction **24**, and this flow conveys downhole device **90** in downhole direction **24**, as illustrated in dash-dot lines in FIG. **1**. The threshold outflow pressure differential generally is specified, or selected, to be greater than a hydrostatic pressure experienced, or expected to be experienced, by the pump-through standing valve when the conveyance fluid is not provided to the tubular conduit. As examples, the threshold outflow pressure differential may be at least 105%, at least 110%, at least 120%, at least 130%, at least 140%, at least 150%, or at least 200% of the hydrostatic pressure.

Flow of the conveyance fluid conveys downhole device **90** in downhole direction **24** and may permit the downhole device to be conveyed in vertical portion **28** and/or in deviated portion **29** of wellbore **20**. Thus, the downhole device may be conveyed, flowed, and/or positioned within any suitable, or target, portion, or region, of the tubular conduit, as illustrated in dash-dot-dot lines in FIG. **1**.

Subsequent to the downhole device being positioned within the target region of the tubular conduit, flow of the conveyance fluid into the wellbore tubular may be ceased, thereby permitting the outflow pressure differential to decrease to less than the threshold outflow pressure differential and causing pump-through standing valve **100** to restrict flow of the conveyance fluid therethrough. The internal pressure then may be decreased such that an inflow pressure differential is at least, or exceeds, a threshold inflow pressure differential. The inflow pressure differential is defined when the external pressure exceeds the internal pressure. When the inflow pressure differential is at least the threshold inflow pressure differential, a fluid inflow of wellbore fluid **26** may flow into tubular conduit **52** from subterranean formation **42** via pump-through standing valve **100**, thereby permitting production of the wellbore fluid.

It is within the scope of the present disclosure that pump-through standing valve **100** may be positioned within wellbore **20** and/or operatively attached to wellbore tubular **50** in any suitable manner and/or with any suitable timing. As an example, pump-through standing valve **100** may be operatively attached to wellbore tubular **50** prior to the wellbore tubular being positioned within the subterranean formation. Under these conditions, the pump-through standing valve may function as a pressure relief valve that prevents over-pressurization of the wellbore tubular during pressure testing thereof. As another example, the pump-through standing valve may be flowed into the subterranean formation, via tubular conduit **52**, subsequent to the wellbore tubular being positioned within the subterranean formation.

FIG. **2** is a schematic representation of pump-through standing valves **100**, according to the present disclosure, while FIGS. **3-6** are less schematic views of a pump-through standing valve **100**, according to the present disclosure. FIGS. **2-6** may include and/or be more detailed views of pump-through standing valve **100** of FIG. **1**. As such, any of the structures, functions, and/or features discussed herein with reference to pump-through standing valves **100** of FIG. **1** may be included in and/or utilized with pump-through standing valves **100** of FIGS. **2-6** without departing from the scope of the present disclosure. Similarly, any pump-through standing valve **100** of any of FIGS. **2-6** may be included in and/or utilized with wells **10** of FIG. **1** without departing from the scope of the present disclosure.

Pump-through standing valves **100** include a valve body **110** including a wellbore-exposed region **102** and a tubular conduit-exposed region **104**, which are discussed in more detail herein with reference to FIG. **1**. Pump-through standing valves **100** also include a standing valve **120**, which is at least partially formed within the valve body, and a flow-through valve **140**, which also is at least partially formed within the valve body. Pump-through standing valve **100** additionally or alternatively may be referred to herein as including a plurality of valve members **111**, with these valve members **111** defining valve body **110**, standing valve **120**, and/or flow-through valve **140**.

As also discussed herein with reference to FIG. **1** and illustrated in FIG. **2**, standing valve **120** is configured to permit a fluid inflow **60**, from subterranean formation **20** and into tubular conduit **52**, when the inflow pressure differential is at least the threshold inflow pressure. In addition, standing valve **120** also is configured to resist a fluid outflow **70** from the tubular conduit and into the subterranean formation. In contrast, flow-through valve **140** is configured to permit fluid outflow **70** when an outflow pressure differential is at least the threshold outflow pressure differential and to restrict the fluid outflow when the outflow pressure differential is less than the threshold outflow pressure differential.

Standing valve **120** may include, or be, any suitable structure that may selectively permit the fluid inflow and also resist the fluid outflow, at least when the outflow pressure differential is less than the threshold outflow pressure differential. As an example, standing valve **120** may include, or be, a check valve **124**, which also may be referred to herein as a standing check valve **124**.

Standing valve **120** includes a standing valve fluid conduit **122**, which extends between wellbore-exposed region **102** and tubular conduit-exposed region **104** of valve body **110**. Standing valve **120** also includes a standing valve flow control device **130**. Standing valve flow control device **130** is configured to permit the fluid inflow via standing valve fluid conduit **122** and also to resist the fluid outflow via the standing valve fluid conduit. Examples of the standing valve flow control device include a ball **134** and seat **136** and/or a flapper **138**.

As another example, and as illustrated in FIG. **2**, standing valve **120** may include a standing valve biasing mechanism **132**. Standing valve biasing mechanism **132**, when present, may be configured to bias standing valve **120** to a standing valve closed position. In addition, the standing valve biasing mechanism also may be configured to permit standing valve **120** to transition to a standing valve open position when the inflow pressure differential is at least the threshold inflow pressure differential. When in the standing valve closed position, the standing valve flow control device restricts fluid flow through the standing valve fluid conduit. When in the standing valve open position, standing valve **120** permits the fluid inflow.

Standing valve biasing mechanism **132** may have any suitable structure and/or structures. As examples, the standing valve biasing mechanism may include one or more of a spring, a resilient material, a gravitational force, and/or an elastomeric material.

The threshold inflow pressure differential may have any suitable value. As examples, a magnitude of the threshold inflow pressure differential may be at most 25%, at most 10%, at most 5%, at most 1%, or at most 0.1% of the threshold outflow pressure differential, or of a magnitude of the threshold outflow pressure differential. As additional examples, the threshold inflow pressure differential may be at most 100 kilopascals (kPa), at most 50 kPa, at most 25 kPa, at most 10 kPa, or at most 1 kPa.

Flow-through valve **140** may include, or be, any suitable structure that may selectively permit the fluid outflow when the outflow pressure differential exceeds the threshold outflow pressure differential and that also may selectively restrict the fluid outflow when the outflow pressure differential is less than the threshold outflow pressure differential. As an example, flow-through valve **140** may include, or be, a check valve **144**, or a flow-through check valve **144**.

Flow-through valve **140** includes a flow-through valve fluid conduit **142**, which extends between wellbore-exposed region **102** and tubular conduit-exposed region **104**. Flow-through valve **140** also includes a flow-through valve flow control device **150**. Flow-through valve flow control device **150** is configured to selectively permit the fluid outflow via the flow-through valve fluid conduit when the outflow pressure differential is at least the threshold outflow pressure differential. In addition, the flow-through valve flow control device also is configured to selectively restrict the fluid outflow via the flow-through valve fluid conduit when the outflow pressure differential is less than the threshold outflow pressure differential.

The threshold outflow pressure differential may have and/or define any suitable value, or magnitude. As examples, the threshold outflow pressure differential may be at least 0.5 megapascals (MPa), at least 1 MPa, at least 10 MPa, at least 20 MPa, or at least 100 MPa. As additional examples, the threshold outflow pressure differential may be at most 70 MPa, at most 60 MPa, at most 50 MPa, at most 40 MPa, or at most 30 MPa.

It is within the scope of the present disclosure that standing valve fluid conduit **122** may be at least partially, or even completely, separate, distinct, and/or spaced-apart from flow-through valve fluid conduit **142**. Additionally or alternatively, it is also within the scope of the present disclosure that standing valve fluid conduit **122** may be at least partially, or even completely, coextensive with flow-through valve fluid conduit **142** and/or that the standing valve fluid conduit and the flow-through valve fluid conduit may be the same fluid conduit. Similarly, standing valve flow control device **130** may be at least partially, or even completely, distinct from the flow-through valve flow control device and/or may include, or be, the flow-through valve flow control device.

When the flow-through valve fluid conduit is at least partially distinct from the standing valve fluid conduit, each fluid conduit may be sized for a desired fluid flow rate therethrough. As an example, the fluid conduits may be sized such that the fluid inflow, via the standing valve fluid conduit, is greater than the fluid outflow, via the flow-through valve fluid conduit. With this in mind, a ratio of an average, or minimum, transverse cross-sectional area of the standing valve fluid conduit to an average, or minimum, transverse cross-sectional area of the flow-through valve fluid conduit may be at least 1, at least 2.5, at least 5, at least 10, or at least 20.

Flow-through valve flow control device **150** may include any suitable structure and/or structures. As an example, the flow-through valve flow control device may include a flow-through valve biasing mechanism **152** configured to resist the fluid outflow until the outflow pressure differential is at least the threshold outflow pressure differential. The flow-through valve flow control device also may be configured to resist the fluid inflow via the flow-through valve fluid conduit; however, this is not required of all embodiments, including those embodiments in which the flow-through valve fluid conduit includes, or is, the standing valve fluid conduit. Examples of the flow-through valve flow control device may include one or more of a bellows **153**, a diaphragm **154**, a bearing **155**, a ball **156**, a seat **157**, and/or a flapper **158**.

Flow-through valve **140** may have and/or define a flow-through valve open state, or an open state, in which the flow-through valve permits the fluid outflow, and a flow-through valve closed state, or a closed state, in which the flow-through valve resists the fluid outflow. In addition, the flow-through valve may be configured to transition, or to selectively transition, between the flow-through valve open state and the flow-through valve closed state based upon, based solely upon, and/or based entirely upon the outflow pressure differential. Stated another way, the flow-through valve flow control device may be pressure-actuated. Stated yet another way, the flow-through valve flow control device may not be electrically actuated. Stated another way, the flow-through valve may be free of an electronic controller and/or may not be electrically controlled.

As illustrated in dashed lines in FIG. **2**, pump-through standing valve **100** also may include an inlet screen **190**. Inlet screen **190**, when present, may be adapted, configured, designed, and/or constructed to restrict a flow of a particulate material into standing valve fluid conduit **122** from wellbore-exposed region **102** of valve body **110**.

As also illustrated in dashed lines in FIG. **2**, valve body **110** may include a fish-neck **112**, which also may be referred to herein as a retrieval neck **112**, as a retrieval fixture **112**, and/or as a connection point **112**. Fish-neck **112**, when present, may be configured to permit and/or facilitate retrieval of pump-through standing valve **100** from tubular conduit **52** while the wellbore tubular is positioned within the wellbore.

It is within the scope of the present disclosure that pump-through standing valve **100**, including valve body **110**, standing valve **120**, flow-through valve **140**, and/or any suitable valve member **111** thereof, may be formed and/or defined from any suitable material and/or materials. Examples of such materials include one or more of a metallic material, an elastomeric material, a resilient material, and/or a polymeric material.

FIGS. **3-6** provide more detailed illustrations of an example of a pump-through standing valve **100** according to the present disclosure. More specifically, FIG. **3** is a cross-sectional view of pump-through standing valve **100** illustrating flow-through valve **140** thereof in a closed state **146**, and FIG. **4** is a top view of the pump-through standing valve of FIG. **3**. In addition, FIG. **5** is a cross-sectional view of pump-through standing valve **100** of FIGS. **3-4** illustrating flow-through valve **140** in an open state **148**, and FIG. **6** is a top view of the pump-through standing valve of FIG. **5**.

FIGS. **3-6** may include and/or be more detailed and/or less schematic views of pump-through standing valve **100** of FIG. **2**. As such, any of the structures, functions, and/or features discussed herein with reference to FIG. **2** may be included in and/or utilized with pump-through standing valves **100** of FIGS. **3-6** without departing from the scope of the present disclosure. Similarly, any of the structures, functions, and/or features discussed herein with reference to pump-through standing valves **100** any of FIGS. **3-6** may be included in and/or utilized with pump-through standing valves **100** of FIG. **2** without departing from the scope of the present disclosure.

In the example of FIGS. **3-6**, valve body **110** of pump-through standing valve **100** defines a body opening **114**, which extends between wellbore-exposed region **102** and tubular conduit-exposed region **104**. Pump-through standing valve **100** of FIGS. **3-6** also includes a ball, or sealing ball, **134** and a sealing ball retention region **182** that is configured to retain the sealing ball. Pump-through standing valve **100** further includes a conduit-exposed valve plate **160** and a wellbore-exposed valve plate **170**.

Conduit-exposed valve plate **160** extends across a first transverse cross-section of body opening **114** and defines a first conduit-exposed plate side **161** and an opposed second conduit-exposed plate side **162**. Conduit-exposed valve plate **160** is exposed to fluid conduit **52** in that the conduit-exposed valve plate includes a region, or face, (i.e., first conduit-exposed plate side **161**) that faces toward, is in fluid contact with, and/or at least partially defines tubular conduit **52** when pump-through standing valve **100** is operatively attached to the tubular conduit, as illustrated in FIG. **1**.

Returning to FIGS. **3-6**, Conduit-exposed valve plate **160** also defines a first conduit-exposed plate aperture **163** and at least one second conduit-exposed plate aperture **164**. First conduit-exposed plate aperture **163** is defined within a central region of the conduit-exposed valve plate and extends between the first conduit-exposed plate side and the second conduit-exposed plate side. Second conduit-exposed plate aperture **164** is defined within a peripheral region of the conduit-exposed valve plate and also extends between the first conduit-exposed plate side and the second conduit-exposed plate side.

Conduit-exposed valve plate **160** further defines a seat, or a ball seat, **136**. Ball seat **136** defines at least a portion, such as an entrance, of first conduit-exposed plate aperture **163** and is defined on first conduit-exposed plate side **161**. In addition, ball seat **136** is shaped to form a fluid seal with sealing ball **134** and defines at least a portion of sealing ball retention region **182**.

Wellbore-exposed valve plate **170** extends across a second transverse cross-section of body opening **114** and defines a first wellbore-exposed plate side **171** and an opposed second wellbore-exposed plate side **172**. Wellbore-exposed valve plate **170** is exposed to wellbore **20** in that the wellbore-exposed valve plate includes a region, or face, (i.e., first wellbore-exposed plate side **171**) that faces toward and/or is in fluid contact with wellbore **20** when pump-through standing valve **100** is positioned within subterranean formation **42** (illustrated in FIG. **1**).

Wellbore-exposed valve plate **170** also defines a first wellbore-exposed plate aperture **173** and at least one second wellbore-exposed plate aperture **174**. First wellbore-exposed plate aperture **173** is defined within a central region of the wellbore-exposed valve plate and extends between the first wellbore-exposed plate side and the second wellbore-exposed plate side. Second wellbore-exposed plate aperture is defined within a peripheral region of the wellbore-exposed valve plate and also extends between the first wellbore-exposed plate side and the second wellbore-exposed plate side. In addition, second wellbore-exposed plate side **172** faces toward, contacts, and/or mechanically contacts second conduit-exposed plate side **162**.

As illustrated in FIGS. **3-6**, and regardless of whether flow-through valve **140** is in closed state **146** of FIGS. **3-4** or open state **148** of FIGS. **5-6**, first conduit-exposed plate aperture **163** and first wellbore-exposed plate aperture **173** are aligned with one another to define standing valve fluid conduit **122**. In addition, and as illustrated in FIG. **3**, sealing ball **134** is free to move, within sealing ball retention region **182**, between at least a sealed configuration, as illustrated in dashed lines, and an unsealed configuration, as illustrated in solid lines. When in the sealed configuration, the sealing ball forms the fluid seal with ball seat **136** and resists the fluid outflow from tubular conduit **52** into subterranean formation **20**. Conversely, when in the unsealed configuration, sealing ball **134** does not form the fluid seal with the ball seat and/or permits fluid flow between the tubular conduit and the subterranean formation. A fluid inflow from subterranean formation **20** and into tubular conduit **52**, via standing valve fluid conduit **122**, tends to urge sealing ball **134** toward the unsealed configuration, while a fluid outflow from the tubular conduit into the subterranean formation tends to urge the sealing ball toward the sealed configuration. Thus, sealing ball **134** and ball seat **136** may be referred to herein as together defining standing valve flow control device **130**.

Second conduit-exposed plate aperture **164** and second wellbore-exposed plate aperture **174** together define flow-through valve fluid conduit **142** of flow-through valve **140**. In addition, conduit-exposed valve plate **160** and wellbore-exposed valve plate **170** are configured for rotation relative to one another and/or to rotate within body opening **114** such that the conduit-exposed valve plate and the wellbore-exposed valve plate together define flow-through valve flow control device **150**.

This rotation may include rotation to closed state **146**, which is illustrated in FIGS. **3-4**. When in the closed state, second conduit-exposed plate aperture **164** and second wellbore-exposed plate aperture **174** are misaligned with one another such that fluid flow, or the fluid outflow, through the flow-through valve fluid conduit is restricted.

This rotation also may include rotation to open state **148**, which is illustrated in FIGS. **5-6**. When in the open state, second conduit-exposed plate aperture **164** and second wellbore-exposed plate aperture **174** are aligned with one another such that fluid flow, or the fluid outflow, through the flow-through valve fluid conduit is permitted. Rotation of the conduit-exposed valve plate and the wellbore-exposed valve plate, relative to one another, may be controlled and/or regulated by a rotation-regulating structure **195**.

As an example, and when the inflow pressure differential is at least a threshold inflow pressure differential sufficient to unseat sealing ball **134** from ball seat **136**, sealing ball **134** may move to the configuration that is illustrated in solid lines in FIG. **3**, thereby permitting the fluid inflow from subterranean formation **20** and/or into tubular conduit **52**. When the inflow pressure differential is at least the threshold inflow pressure differential, the outflow pressure differential is negative and/or is less than the threshold outflow pressure differential. As such, conduit-exposed valve plate **160** and wellbore-exposed valve plate **170** are rotated relative to one another such that second conduit-exposed plate aperture **164** and second wellbore-exposed plate aperture **174** are misaligned, or such that flow-through valve **140** is in closed state **146**. Thus, fluid flow through flow-through valve fluid conduit **142** is restricted, occluded, resisted, and/or blocked.

In contrast, when the outflow pressure differential is at least the threshold outflow pressure differential, the outflow pressure differential urges sealing ball **134** into sealing contact with ball seat **136**, thereby resisting fluid outflow via standing valve fluid conduit **122**. This is illustrated in FIG. **5**. However, and as illustrated in FIGS. **5-6**, when the outflow pressure differential exceeds the threshold outflow pressure differential, conduit-exposed valve plate **160** and wellbore-exposed valve plate **170** rotate, relative to one another, to open state **148** and/or such that second conduit-exposed plate aperture **164** is aligned with second wellbore-exposed plate aperture **174**. As such, fluid outflow through flow-through valve fluid conduit **142** is permitted. When the outflow pressure differential decreases to less than the threshold outflow pressure differential, conduit-exposed valve plate **160** and wellbore-exposed valve plate **170** return to closed state **146**, as illustrated in FIGS. **3-4**.

FIG. **7** is a flowchart depicting methods **200**, according to the present disclosure, of utilizing a pump-through standing valve to deploy a downhole device within a tubular conduit of a wellbore tubular. The wellbore tubular extends within a wellbore that extends within a subterranean formation, and a pump-through standing valve assembly, such as pump-through standing valve **100** of FIGS. **1-6**, is operatively attached to a downhole portion of the wellbore tubular.

Methods **200** include positioning the downhole device at **210** and may include permitting a gravitational force to convey the downhole device at **220**. Methods **200** further include providing a conveyance fluid to a tubular conduit at **230**, initiating flow of the conveyance fluid from the tubular conduit at **240**, and conveying the downhole device at **250**. Methods **200** also include ceasing the providing the conveyance fluid at **260**, restricting flow of the conveyance fluid from the tubular conduit at **270**, decreasing an internal pressure within the tubular conduit at **280**, and receiving a wellbore fluid into the tubular conduit at **290**.

Positioning the downhole device at **210** may include positioning the downhole device within an uphole region, or portion, of the tubular conduit, such as uphole portion **54** of FIG. **1**. The downhole device may include any suitable downhole device, examples of which are discussed herein with reference to downhole device **90** of FIG. **1**. One specific example of the downhole device is a pump.

Permitting the gravitational force to convey the downhole device at **220** may include permitting any suitable gravitational force, which acts on the downhole device, to provide a motive force for conveyance of, or to accelerate, the downhole device in the downhole direction within the tubular conduit. The permitting at **220** may include waiting at least a threshold permitting time and/or waiting until the downhole device has been conveyed, via the gravitational force, at least a threshold fraction of a length of a vertical, or at least substantially vertical, portion of the tubular conduit. Examples of the threshold fraction of the length of the vertical portion of the tubular conduit include at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 95%, at least 99%, or at least substantially 100% of the length of the vertical portion of the tubular conduit. The permitting at **220** may be performed subsequent to the positioning at **210**, prior to the providing at **230**, and/or prior to the initiating at **240**.

Providing the conveyance fluid to the tubular conduit at **230** may include providing the conveyance fluid to the uphole region of the tubular conduit and/or providing the conveyance fluid from a surface region. The providing at **230** also may include providing to pressurize the tubular conduit and/or providing to establish an outflow pressure differential within the tubular conduit. As discussed herein, the outflow pressure differential may be defined when an internal pressure exerted on a tubular conduit-exposed region of the pump-through standing valve exceeds an external pressure exerted on a wellbore-exposed region of the pump-through standing valve, and the providing at **230** may include providing such that the outflow pressure differential exceeds a threshold outflow pressure differential. Stated another way, the outflow pressure differential may be a pressure differential in which a pressure within the tubular conduit exceeds a pressure external to the tubular conduit and/or a pressure differential that provides a motive force for flow of the conveyance fluid out of the tubular conduit and/or into the subterranean formation. Examples of the threshold outflow pressure differential are disclosed herein.

Initiating flow of the conveyance fluid from the tubular conduit at **240** may include initiating the flow of the conveyance fluid from the tubular conduit via a flow-through valve fluid conduit of the pump-through standing valve. Examples of the flow-through valve fluid conduit are discussed herein with reference to flow-through valve fluid conduit **142** of FIGS. **2-6**. The flow-through valve fluid conduit may form a portion of a flow-through valve of the pump-through standing valve, examples of which are discussed herein with reference to flow-through valve **140** of FIGS. **2-6**.

The initiating at **240** may be responsive to the outflow pressure differential exceeding the threshold outflow pressure differential. Stated another way, and as discussed herein, the flow-through valve may transition from a closed state, such as closed state **146** of FIGS. **3-4**, to an open state, such as open state **148** of FIGS. **5-6**. This transition may be responsive to the outflow pressure differential exceeding the threshold outflow pressure differential, and the initiating at **240** may include transitioning the flow-through valve from the closed state to the open state.

Conveying the downhole device at **250** may include conveying the downhole device within the tubular conduit and/or in a downhole direction. This may include conveying, or flowing, the downhole device with and/or within the conveyance fluid, such as within a flow of the conveyance fluid that flows from the uphole portion of the tubular conduit and to, or through, the pump-through standing valve. The conveying at **250** further may include conveying to position the downhole device within a target, desired, or specified region of the tubular conduit and may be responsive to the initiating at **240**.

As discussed in more detail herein, the well may include a deviated portion, such as deviated portion **29** of FIG. **1**. Under these conditions, the conveying at **250** may include conveying the downhole device through and/or within the deviated portion.

Ceasing the providing the conveyance fluid at **260** may include ceasing, or stopping, flow of the conveyance fluid into the tubular conduit and/or into the uphole portion of the tubular conduit. The ceasing at **260** may be subsequent, or responsive, to the downhole device being positioned within, or reaching, the target region of the tubular conduit.

Additionally or alternatively, the ceasing at **260** may include ceasing such that the outflow pressure differential decreases to less than the threshold outflow pressure differential. Stated another way, the providing at **230** may include continuously, or at least substantially continuously, providing the conveyance fluid to the tubular conduit and/or providing to maintain the outflow pressure differential at, or above, the threshold outflow pressure differential, at least during the initiating at **240** and the conveying at **250**. However, and subsequent to the ceasing at **260**, the outflow pressure differential may no longer be maintained above the threshold outflow pressure differential.

Restricting flow of the conveyance fluid from the tubular conduit at **270** may include restricting flow of the conveyance fluid through the flow-through valve fluid conduit. This may include transitioning the flow-through valve from the open state to the closed state and may be responsive to the outflow pressure differential decreasing to less than the threshold outflow pressure differential.

Decreasing the internal pressure within the tubular conduit at **280** may include decreasing such that an inflow pressure differential is at least a threshold inflow pressure differential. The inflow pressure differential may be a pressure differential in which the external pressure exerted on the wellbore-exposed region of the pump-through standing valve exceeds the internal pressure exerted on the tubular conduit-exposed region of the pump-through standing valve. Stated another way, the inflow pressure differential may be a pressure differential that provides a motive force for flow of a wellbore fluid into the tubular conduit from the subterranean formation. Stated yet another way, the inflow pressure differential may be opposed to, have an opposite sign from, and/or have an opposite polarity from the outflow pressure differential.

When the downhole device includes the pump, the decreasing at **280** may include decreasing with, via, and/or utilizing the pump, such as by pumping the wellbore fluid to the surface region with the pump. The decreasing at **280** may be performed subsequent to the positioning at **210**, subsequent to the permitting at **220**, subsequent to the providing at **230**, subsequent to the initiating at **240**, subsequent to the conveying at **250**, subsequent to the ceasing at **260**, and/or subsequent to the restricting at **270**.

Receiving the wellbore fluid into the tubular conduit at **290** may include receiving the wellbore fluid, which may include a reservoir fluid, from the subterranean formation via a standing valve fluid conduit of the pump-through standing valve. An example of the standing valve fluid conduit includes standing valve fluid conduit **122** that forms a portion of standing valve **120** of FIGS. **2-6**.

The receiving at **290** may be subsequent, or responsive, to the decreasing at **280**. In addition, and as discussed herein with reference to FIGS. **1-6**, methods **200** further may include resisting flow of the conveyance fluid from the tubular conduit and into the subterranean formation, via the pump-through valve fluid conduit, at least during the providing at **230**, during the initiating at **240**, and during the conveying at **250**.

In the present disclosure, several of the illustrative, non-exclusive examples have been discussed and/or presented in the context of flow diagrams, or flow charts, in which the methods are shown and described as a series of blocks, or steps. Unless specifically set forth in the accompanying description, it is within the scope of the present disclosure that the order of the blocks may vary from the illustrated order in the flow diagram, including with two or more of the blocks (or steps) occurring in a different order and/or concurrently.

As used herein, the term "and/or" placed between a first entity and a second entity means one of (1) the first entity, (2) the second entity, and (3) the first entity and the second entity. Multiple entities listed with "and/or" should be construed in the same manner, i.e., "one or more" of the entities so conjoined. Other entities may optionally be present other than the entities specifically identified by the "and/or" clause, whether related or unrelated to those entities specifically identified. Thus, as a non-limiting example, a reference to "A and/or B," when used in conjunction with open-ended language such as "comprising" may refer, in one embodiment, to A only (optionally including entities other than B); in another embodiment, to B only (optionally including entities other than A); in yet another embodiment, to both A and B (optionally including other entities). These entities may refer to elements, actions, structures, steps, operations, values, and the like.

As used herein, the phrase "at least one," in reference to a list of one or more entities should be understood to mean at least one entity selected from any one or more of the entity in the list of entities, but not necessarily including at least one of each and every entity specifically listed within the list of entities and not excluding any combinations of entities in the list of entities. This definition also allows that entities may optionally be present other than the entities specifically identified within the list of entities to which the phrase "at least one" refers, whether related or unrelated to those entities specifically identified. Thus, as a non-limiting example, "at least one of A and B" (or, equivalently, "at least one of A or B," or, equivalently "at least one of A and/or B") may refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including entities other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including entities other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other entities). In other words, the phrases "at least one," "one or more," and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B and C," "at least one of A, B, or C," "one or more of A, B, and C," "one or more of A, B, or C" and "A, B, and/or C" may mean A alone, B alone, C alone, A and B together, A and C together, B and C together, A, B and C together, and optionally any of the above in combination with at least one other entity.

In the event that any patents, patent applications, or other references are incorporated by reference herein and (1) define a term in a manner that is inconsistent with and/or (2) are otherwise inconsistent with, either the non-incorporated portion of the present disclosure or any of the other incorporated references, the non-incorporated portion of the present disclosure shall control, and the term or incorporated disclosure therein shall only control with respect to the reference in which the term is defined and/or the incorporated disclosure was present originally.

As used herein the terms "adapted" and "configured" mean that the element, component, or other subject matter is designed and/or intended to perform a given function. Thus, the use of the terms "adapted" and "configured" should not be construed to mean that a given element, component, or other subject matter is simply "capable of" performing a given function but that the element, component, and/or other subject matter is specifically selected, created, implemented, utilized, programmed, and/or designed for the purpose of performing the function. It is also within the scope of the present disclosure that elements, components, and/or other recited subject matter that is recited as being adapted to perform a particular function may additionally or alternatively be described as being configured to perform that function, and vice versa.

As used herein, the phrase, "for example," the phrase, "as an example," and/or simply the term "example," when used with reference to one or more components, features, details, structures, embodiments, and/or methods according to the present disclosure, are intended to convey that the described component, feature, detail, structure, embodiment, and/or method is an illustrative, non-exclusive example of components, features, details, structures, embodiments, and/or methods according to the present disclosure. Thus, the described component, feature, detail, structure, embodiment, and/or method is not intended to be limiting, required, or exclusive/exhaustive; and other components, features, details, structures, embodiments, and/or methods, including structurally and/or functionally similar and/or equivalent components, features, details, structures, embodiments, and/or methods, are also within the scope of the present disclosure.

INDUSTRIAL APPLICABILITY

The pump-through standing valves, wells, and methods disclosed herein are applicable to the oil and gas industries.

It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower, or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

The invention claimed is:

1. A pump-through standing valve configured to be operatively attached to a wellbore tubular, which defines a tubular conduit and extends within a wellbore that extends within a subterranean formation, the pump-through standing valve comprising:

a single valve body including a wellbore-exposed region and a tubular conduit-exposed region, wherein the valve body is configured to interface with a single fluid passage at each of the wellbore-exposed region and the tubular conduit-exposed region;

a standing valve at least partially formed within the valve body, the standing valve comprising:

(i) a standing valve fluid conduit extending longitudinally through the valve body along a central axis and between the wellbore-exposed region of the valve body and the tubular conduit-exposed region of the valve body; and

(ii) a standing valve flow control device configured move axially along the valve body to permit a fluid inflow, via the standing valve fluid conduit, from the wellbore into the tubular conduit and also to resist a fluid outflow, via the standing valve fluid conduit, from the tubular conduit into the subterranean formation; and

a flow-through valve at least partially formed within the valve body, the flow-through valve comprising:

(i) a flow-through valve fluid conduit fluidly extending between the wellbore-exposed region of the valve body and the tubular conduit-exposed region of the valve body; and

(ii) a flow-through valve flow control device configured to rotate about the central axis with respect to a portion of the valve body to selectively permit the fluid outflow from the tubular conduit exposed region to the wellbore exposed region via the flow-through valve fluid conduit when an outflow pressure differential across the flow-through valve flow control device is at least a threshold outflow pressure differential,

wherein the outflow pressure differential is a pressure differential in which a pressure exerted on the tubular conduit-exposed region of the valve body exceeds a pressure exerted on the wellbore-exposed region of the valve body,

wherein the flow-through valve flow control device is configured to rotate about the central axis with respect to the portion of the valve body to selectively restrict the fluid outflow to the wellbore-exposed region when the outflow pressure differential is less than the threshold outflow pressure differential, and

wherein the pump-through standing valve is configured to provide fluid flow in a single direction between the wellbore-exposed region and the tubular conduit-exposed region through one of the flow-through valve and the standing valve based on the pressure differential between the wellbore-exposed region and the tubular conduit-exposed region.

2. The pump-through standing valve of claim **1**, wherein the standing valve includes a standing valve biasing mechanism configured to bias the standing valve to a standing valve closed position and to permit the standing valve to transition to a standing valve open position when an inflow pressure differential is at least a threshold inflow pressure differential, wherein, when in the standing valve closed position, the standing valve flow control device restricts fluid flow through the standing valve fluid conduit, wherein, when in the standing valve open position, the standing valve permits the fluid inflow, and further wherein the inflow pressure differential is a pressure differential in which the pressure exerted on the wellbore-exposed region of the valve body exceeds the pressure exerted on the tubular conduit-exposed region of the valve body.

3. The pump-through standing valve of claim **2**, wherein the standing valve biasing mechanism includes at least one of:

(i) a spring;
(ii) a resilient material;
(iii) a gravitational force; and
(iv) an elastomeric material.

4. The pump-through standing valve of claim **1**, wherein the standing valve flow control device includes at least one of:

(i) a ball and seat; and
(ii) a flapper.

5. The pump-through standing valve of claim **1**, wherein the threshold outflow pressure differential is at least 0.5 megapascals (MPa) and at most 70 megapascals (MPa).

6. The pump-through standing valve of claim **1**, wherein the standing valve fluid conduit includes at least one of:

(i) is distinct from the flow-through valve fluid conduit;
(ii) is at least partially coextensive with the flow-through valve fluid conduit; and
(iii) is the flow-through valve fluid conduit.

7. The pump-through standing valve of claim **1**, wherein the standing valve flow control device includes at least one of:

(i) is distinct from the flow-through valve flow control device; and
(ii) includes the flow-through valve flow control device.

8. The pump-through standing valve of claim **1**, wherein a ratio of an average transverse cross-sectional area of the standing valve fluid conduit to an average transverse cross-sectional area of the flow-through valve fluid conduit is at least 1.

9. The pump-through standing valve of claim **1**, wherein the flow-through valve flow control device includes a flow-through valve biasing mechanism configured to resist the fluid outflow until the outflow pressure differential is at least the threshold outflow pressure differential.

10. The pump-through standing valve of claim **1**, wherein the flow-through valve flow control device includes at least one of:

(i) a bellows;
(ii) a diaphragm;
(iii) a bearing;
(iv) a ball;
(v) a seat;
(vi) a flapper
(vii) a rotating plate with an aperture
(viii) a rotating disc with an aperture
(ix) a sliding sleeve
(x) a choke bean, and
(xi) a biasing device.

11. The pump-through standing valve of claim **1**, wherein the flow-through valve flow control device is pressure-actuated.

12. The pump-through standing valve of claim **1**, wherein the flow-through valve defines a flow-through valve open state, in which the flow-through valve permits the fluid outflow, and a flow-through valve closed state, in which the flow-through valve restricts the fluid outflow.

13. The pump-through standing valve of claim **12**, wherein the flow-through valve is configured to selectively transition between the flow-through valve open state and the flow-through valve closed state based solely on the outflow pressure differential.

14. The pump-through standing valve of claim **12**, wherein the flow-through valve is biased to the flow-through valve closed state.

15. The pump-through standing valve of claim **1**, wherein the flow-through valve flow control device further is configured to resist the fluid inflow via the flow-through valve fluid conduit.

16. A well, comprising:

a wellbore extending within a subterranean formation;

a wellbore tubular defining a tubular conduit and extending within the wellbore; and the pump-through standing valve of claim **1**, wherein the pump-through standing valve is operatively attached to a downhole portion of the wellbore tubular such that the wellbore-exposed region is exposed to the wellbore and also such that the tubular conduit-exposed region is exposed to the tubular conduit.

17. The well of claim **16**, wherein the threshold outflow pressure differential is selected to be greater than a hydrostatic pressure experienced by the flow-through valve.

18. The pump-through standing valve of claim **1**, wherein the standing valve comprises a single standing valve flow control device.

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